

EFFECT OF BIWEEKLY SHOOT TIP HARVESTS ON THE  
GROWTH AND YIELD OF "GEORGIA JET" SWEET POTATO  
GROWN HYDROPONICALLY

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ABSTRACT

Sweet potato shoot tips have been shown to be a nutritious green vegetable. This study was conducted to determine the effect of biweekly shoot tip harvests on the growth and yield of "Georgia Jet" sweet potato grown in the greenhouse using the nutrient film technique (NFT). The nutrient solution consisted of a modified half Hoagland solution. Biweekly shoot tip harvests, beginning 42 days after planting, provided substantial amounts of vegetable greens and did not affect the fresh and dry foliage weights or the storage root number and fresh and dry storage root weights at final harvest. The rates of anion and cation uptake were not affected by tip harvests.

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## **Introduction**

In a number of countries where sweet potato is a staple, the shoot tips (top 10 cm) are eaten as vegetable greens. Villareal et al. (1979) reported that in Southeast Asian countries yields of sweet potato shoot tips consumed as vegetables varied from 10 to 16 t/ha while marketable roots for those cultivars studied as possible dual vegetable crops varied from 1 to 16 t/ha. In West Africa, Liberians consume sweet potato tips on a daily basis (As-Saqui, 1982). Pace et al. (1985a,b) reported that sweet potato green tips are as nutritious in Ca and Fe as are other leafy vegetables such as spinach, mustard, turnip and collard greens and can be similarly prepared. They suggested that sweet potato tips have potential as a new food in the U.S.

Because of its value as a dual vegetable in that both shoot tips and storage roots can be eaten, sweet potatoes have been selected by the National Aeronautics and Space Administration as a potential food source for space missions. Investigations are underway to determine the optimum conditions for production of sweet potatoes in Controlled Ecological Life Support Systems (CELSS). One aspect of this research is to study the effect of periodic harvesting of sweet potato shoot tips on the growth of the plant and its storage root yield.

Dahniya (1980) investigated the effect of leaf harvests and topping on the foliage and root yields of sweet potato. He showed that topping shoot tips resulted in 34 to 42% less shoot yield than did cutting plants at the base of each shoot. Storage root yield was less severely reduced when shoot tips were topped than when vines were cut at the base. Total shoot yield was unaffected when tips were harvested at 2-, 3-, or 4-week intervals.

Bartolini (1981) reported that shoot topping increased storage root yield of sweet potatoes significantly when done between one and two months after planting. Shoot topping beyond two months or continuous topping was detrimental to storage root production. Gonzales et al. (1977) studied the effect of topping and fertilization on yield of sweet potatoes and found that topping reduced storage root yields. The highest storage root yield was obtained from the no topping treatment; successively lower yields were obtained by topping at 3-week intervals and topping at biweekly intervals. In a related study, Hopkinson (1986) investigated the effect of shoot tip harvests of sweet potato at 45, 60 and 75 days after planting. He found that removal of 15 cm from the terminal ends of sweet potato vines at these dates did not significantly reduce storage root yields.

In an open hydroponic system study employing sand as the aggregate, Pace et al. (1988) showed that the dry matter and nutrient content of sweet potato green tips and roots harvested on different dates differed according to cultivar. Loretan et al. (1988) and Hill et al. (1988) also reported that the nutritive quality of storage roots and foliage of hydroponically grown sweet potatoes were similar to field grown sweet potatoes and suggested the crop has high potential for CELSS. However, Hill et al. (1988) reported that there was a higher shoot/storage root ratio, as measured by the harvest index, for sweet potato plants grown using the nutrient film technique (NFT) as compared to those grown using an aggregate. Depending on the cultivar, foliage growth in NFT can be prolific; this can be an advantage for CELSS in that the shoot tips can be cut and used as vegetable greens and the total biomass produced

can be increased. However, too much foliage growth could be a disadvantage because of limited space in the biomass production chamber (BPC) (Prince et al., 1986).

The objective of this study was to evaluate the effect of biweekly cutting of shoot tips on sweet potato plants grown in an NFT system.

## Materials and Methods

Experiments on the effect of harvesting foliage shoot tips were carried out with plants grown in the Tuskegee University NFT system. Three channels, each with its own reservoir, were used with the first and third channels holding four plants each. Shoot tips (10 cm) from plants in the first channel were harvested starting at 42 days after planting and thereafter on a biweekly basis until the end of the experiment (Treatment A). The plants in the third channel were the control and were left intact until harvested at 120 days (Treatment C). The middle channel with no plants was used to monitor water loss due to evaporation for the other treatments.

A modified half Hoagland solution (30.4 liters) was used as the nutrient solution in each tank. The solution pH values were maintained at 6.0 by addition of either NaOH or H<sub>2</sub>SO<sub>4</sub> (Bakker, 1986) while the temperature, salinity and electrical conductivity were recorded at regular intervals. Nutrient solution was pumped to all the channels by a small submersible pump (Teel Model IP680A, 1/200 HP) in the reservoir and the flow rate was maintained at 16 ml s<sup>-1</sup>. Solutions were changed at 2-week intervals and were topped with deionized water if the volume was reduced to 8 liters prior to the 2-week interval. Samples of nutrient solutions from treatments A and C were taken at the time of solution preparation and prior to the solution change and analyzed for Cl, NO<sub>3</sub>, H<sub>2</sub>PO<sub>4</sub> and SO<sub>4</sub> with a Dionex Ion Chromatograph model 4000I. NH<sub>4</sub>, K, Mg, and Ca cations were also analyzed in addition to the anions.

Abaxil stomatal conductance (cm s<sup>-1</sup>) was also measured for five days between 1200 and 1400 h CST. The measurement was made on the third uppermost, fully expanded and unshaded leaf of each plant using a LI-1600 Steady State Porometer (LI-Cor, Inc., Lincoln, NE). If the third leaf was found damaged, measurement was made on the fourth or fifth leaf. The transpiration rate of each plant (ug cm<sup>-2</sup>s<sup>-1</sup>) was also recorded for five days. All five measurements were done during the last quarter of the plant's growth ( 90-100 days after planting).

Each shoot tip harvest of a plant was weighed fresh and again following drying at 70°C for 48 h. At the end of the experiment, all foliage was cut at the base, weighed fresh and dried for 48 h at 70°C and reweighed. The fibrous root mat thickness was measured before it was dried and weighed. Storage roots were counted and weighed fresh. A 25 gram sample of the roots from each plant was taken and dried at 70°C for 48 h in order to find percentage dry matter and storage dry root weight. The amount of solution taken up by the plants in each treatment was calculated by subtracting the volume of water that evaporated out of the middle unplanted channel from the volume of nutrient solution in each of the treatments. The experiment was repeated once. Results of the two experiments were pooled.

## **Results and Discussion**

The biweekly anion ( $\text{Cl}$ ,  $\text{NO}_3$ ,  $\text{H}_2\text{PO}_4$  and  $\text{SO}_4$ ) uptake patterns for both the biweekly harvest and the control treatments were similar and followed the same trend. Uptake of  $\text{NO}_3$  and  $\text{H}_2\text{PO}_4$  for each 2-week period generally increased up to 8 weeks after planting before reaching a relatively steady state uptake rate. Uptake of  $\text{SO}_4$  and  $\text{Cl}$  each increased up to the fourth and sixth week respectively, and subsequently oscillated up and down in value through the 18th week. More  $\text{Cl}$  and  $\text{NO}_3$  were taken up than with the other anions. These results agree with the study by Kirkby (1969) who showed that  $\text{Cl}$  and  $\text{NO}_3$  were taken up more rapidly than  $\text{SO}_4$ . Anion uptake increased with increased plant root formation. The overall uptake patterns of the anions are in agreement with those of Schwartzkopf (1987) using a modified half-Hoagland solution in which lettuce was grown.

The cation ( $\text{NH}_4$ ,  $\text{K}$ ,  $\text{Mg}$  and  $\text{Ca}$ ) uptake pattern as measured on a biweekly basis for both treatments also followed the same trend.  $\text{K}$ ,  $\text{Mg}$ , and  $\text{Ca}$  uptake tended to be higher for the control plants than for plants in which the foliage was harvested. The uptake for these three cations oscillated from the sixth week to the eighteenth week. The nutrient uptakes were in general agreement with the findings of Mengel and Kirkby (1983) that the rate of uptake of each anion and cation specie was dependent on the magnitude of each ionic specie in the nutrient solution.

Both the mean stomatal conductance and the mean transpiration rate for control plants were higher than for those plants with biweekly foliage harvests. The comparative stomatal conductance values were  $1.26 \text{ cm s}^{-2}$  for Treatment C and  $1.00 \text{ cm s}^{-2}$  for Treatment A. The mean transpiration rates were  $8.54$  and  $7.98 \text{ ug cm}^{-2}\text{s}^{-1}$  for treatments C and A respectively. For both treatments the results are within the range of those measured for sweet potatoes grown under ambient and elevated levels of carbon dioxide in open top chambers (Biswas et al., 1985). The higher values obtained for the control, Treatment C, may have caused the higher use of nutrient solution by these plants (170.3 L) compared to Treatment A plants (126.0 L). Since the water loss due to evaporation was taken into account, these figures represent net uptake values. Water as well as light have been reported as two factors that have the greatest influence on stomatal resistance in plants (Turner, 1974).

There were no differences in sweet potato yield components (Tables 1 and 2) for sweet potatoes between Treatment A and Treatment C. However, storage root yields tended to be higher for the control, i.e., fresh storage root weight of 482.5 g/plant as compared to 423.5 g/plant for Treatment A.

Likewise, if biweekly foliage harvests were not included in the totals, the total foliage yield tended to be higher for the control, e.g., fresh weight of 396.8 g/plant as opposed to 329.5 g/plant for Treatment A. However, if the biweekly shoot tip yields were included, the total foliage fresh weight of 433.0 g/plant in Treatment A tended to be higher than the 396.8 g/plant for the control.

Although these yield components were lower than those reported by Hill et al. (1988) for "Georgia Jet" sweet potatoes grown in NFT, the conclusions drawn that there were no differences between treatments were the same as those found by Hopkinson (1986). In field studies with sweet potatoes he found that topping treatments did not significantly affect fresh or dry storage root yield. However, the results are contrary to those reported by Gonzales et al. (1977) for field grown sweet potatoes which showed that topping reduced the storage root yields of sweet potato when shoot tips were harvested on a biweekly basis.

**Table 1. Effect of biweekly topping on storage root yield components\* of "Georgia Jet" sweet potato grown in NFT.**

Treatment	Storage Root			
	No.	Fresh Wt. (g)	Dry Wt. (g)	Dry Matter (%)
A (Biweekly topping)	5.1	423.5	77.7	18.0
C (Control)	6.1	482.5	81.7	16.9
LSD (5%)	NS	NS	NS	NS

\*Mean of eight plants.

The results of these experiments show that harvesting "Georgia Jet" sweet potato shoot tips on a biweekly basis in an NFT system for use as a green vegetable will not affect storage root yield. "Georgia Jet" sweet potato has the potential for serving as a dual purpose food — a green vegetable and a fresh storage root — for long-term manned space missions. Further research on the relationship of shoot topping frequency on storage root yields of selected sweet potato cultivars is needed for CELSS.

**Table 2. Effect of biweekly topping on fibrous roots\* and foliage\* of "Georgia Jet" sweet potato plants grown in NFT.**

Treatment	Fibrous Roots		Foliage
	Dry Wt. (g)	Fresh Wt. (g)	Dry Wt. (g)
A (Biweekly topping)	8.8	329.5 (433.0)**	55.0 (65.9)**
C (Control)	7.9	396.8	62.1
LSD (5%)	NS	NS	NS

\*Mean of eight plants

\*\*Total foliage weight + shoot tips.

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